Niakornak, Greenland. Found 1819. (1 gr., VI.)

Sao Francisco, Brazil. Found 1874. (479 gr., V; 26 gr., VI.)

Nikolojewskaja Wosimskaja, Russia. Found 1883. 87 gr. 8 cm.

Artificial Products.

Glowed Steel. (1 gr., VI.)

Devitrified molten Pitchstone. (VI.)

IX. Duplicates for Exchanges.

In a synoptical collection the duplicates destinated for exchanges should be registered separated from the pieces of the main collection by three reasons: to avoid the constant moving of weights in the catalogue, to avoid parting with specimens, which show important peculiarities and to enable directors or owners of other collections to arrange propositions for exchange.

As the present article has a more theoretical scope, duplicates were not registered at all; they form a series of 90 localities in the weight of together 85 kilograms.

A SYSTEM OF PASSENGER CAR VENTILATION.

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The ventilation of passenger cars is no small problem. The ordinary passenger coach includes about 4,000 cubic feet of space, and the difficulties of the problem will be apparent when it is stated that it is proposed to take into this limited space sixty people, to keep them in that space for from four to six hours at a time, to keep them warm enough for their comfort in winter, to supply them with the necessary amount of fresh air, and at the same time to, as far as possible, exclude objectionable material from without, such as smoke and cinders. It is perhaps not strange, in view of the small space and large number of people and the inclemency of the weather, that progress in the solution of the problem has been slow. It is believed that the system which will be described is a decided step forward in this matter, and while it may not be the final solution, it certainly can be justly claimed that it is a marked amelioriation of the conditions which have prevailed heretofore.

Before proceeding to describe the system, it may perhaps be wise to consider briefly a few preliminary questions as follows:

First, is it possible to properly ventilate a car without having the heating system a part of the ventilating system? It will be quite obvious on a moment's reflection, we think, that in the climate in which we live unwarmed air, especially in view of the large amount of it required, as will appear later, cannot be successfully taken through so small a space as a passenger coach in sufficient quantity to properly ventilate it. Little argument is needed on this point, and in the system to be described the heating system has been regarded as an essential feature. A few proposed systems have ignored the heating system, but none of them, so far as known, can be regarded as efficient in cold weather.

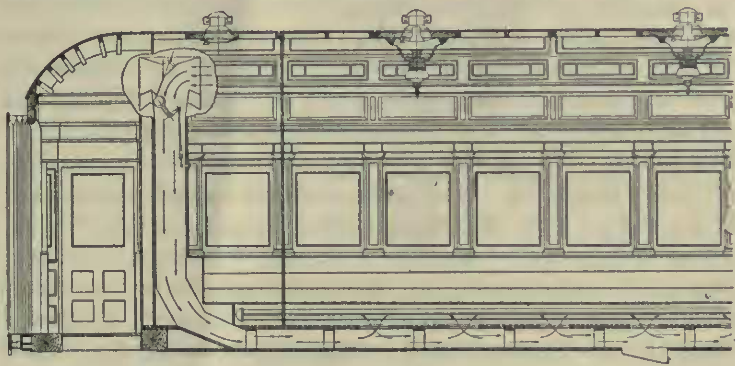
A second point that deserves a moment's attention is, "When can a space be said to be well ventilated, or what is the standard of good ventilation?" It is well known that three things are continually given off from the bodies of human beings which tend to make any space in which they are situated for any length of time have the characteristic which is called "ill ventilated." These three things are carbonic acid, water vapor, and a certain substance which for want of a better name is commonly called "organic matter," and which is believed to be the source of the odor. Of these three, carbonic acid is easily determined. Those who are familiar with the studies that have been devoted to ventilation, and which are described in standard works on Hygiene, are aware that formerly an arbitrary amount of carbonic acid in the air was taken as the measure of good ventilation. It is well known that the ordinary outside air contains about four cubic feet of carbonic acid in 10,000 of air, and formerly it was customary to say that if the carbonic acid in any closed space occupied by human beings did not exceed ten cubic feet per 10,000, the space might be regarded as well ventilated. Later studies seemed to have changed this view, and the test that is now given in the standard works on ventilation is that a space can be said to be well ventilated when a person coming into that space from the outside air does not detect any of the odor which is characteristic of badly ventilated spaces. Quite a large number of analyses have been made to determine how much carbonic acid is characteristic of air of this kind. The best and most careful studies on this subject are probably those given in Parke's *Practical Hygiene*, and it is found that when the carbonic acid naturally in the air, is increased by two cubic feet per 10,000 from human beings, it is possible to begin to detect the odor mentioned. So that when an analysis of the air in any closed space, which is occupied by human beings, shows not more than six cubic feet of carbonic acid per 10,000, it is claimed that the space may be regarded as well ventilated.

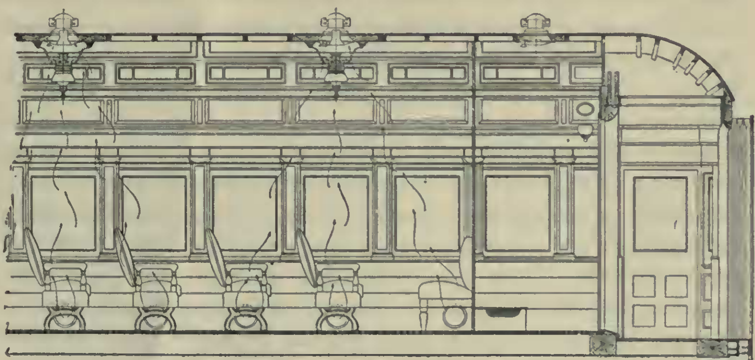
The third point to be discussed is, since carbonic acid is given off from human beings, and since the amount of it in the air from this source is an essential element in ventilation, it is necessary to know how much carbonic acid per person per hour goes into the air. The same authority already quoted, namely, Parke's *Practical Hygiene*, gives the results of a very large number of experiments on this subject. Men usually give off more than women, and children less than either. A man in vigorous work gives off more than in idleness. The mean of a mixed community, such as may be assumed to ride on cars, is 0.60 cubic foot per person per hour. It will be seen in a moment where these figures apply.

Fourth, one of the most important questions in car ventilation is, "How much air per car per hour is it necessary to take through a car in order to have it well ventilated?" If the data above given are to be trusted, it will be evident that when a car contains sixty people, each one giving off on the average 0.60 cubic foot of carbonic acid per hour, there will be per hour thirty-six cubic feet of carbonic acid to deal with, and the problem becomes how much fresh air is it essential to mix with these thirty-six cubic feet of carbonic acid, in order that it may be diluted to such an extent that it will not add to the carbonic acid already in the air, more than two cubic feet per 10,000. The problem may be stated in the form of proportion. If 10,000 cubic feet of air are to contain two cubic feet of carbonic acid in addition to its normal amount how many cubic feet are essential to contain thirty-six? Reducing the proportion and the astounding figure is reached that, in order to have a passenger car well ventilated according to the data already given, it is essential to take through the car 180,000 cubic feet of fresh air per hour. This figure may be stated in another way, and this is the form in which it is usually given in treatises on ventilation, namely, it requires 3,000 cubic feet of fresh air per person per hour to maintain the air in any closed space in the conditions required for good ventilation, according to the standards already mentioned. This is hardly the place to discuss the validity of this figure. There is some difference of opinion as to whether the amount is not excessive, and it is perhaps fair to say that the point cannot be regarded as satisfactorily settled. It may not be amiss to mention that in conversation with Professor Atwater, of the Wesleyan University, Middletown, Conn., who has made a large number of experiments in the human calorimeter, he stated that the inmates of the calorimeter do not complain of drowsiness or of any unpleasant feeling even though the carbonic acid reaches a very much higher figure than anything that has been mentioned, but do complain of drowsiness and languor with occasional headache if the amount of moisture in the air gets much above the normal. It may not be amiss to mention at this point that, in the system of car ventilation to be described, no attempt has been made to get the large amount of air mentioned, namely, 180,000 cubic feet per car per hour. The experimental work has been limited to an attempt to get 60,000 cubic feet of air per car per hour, or about 1,000 cubic feet of fresh air per person per hour.

Fifth. One more question must be discussed a little in order that what follows may be completely understood, namely, how is it possible to measure the amount of air that goes into and out of a car per hour? It may be said that attempts to do this by means of sizes of apertures and velocity of currents have not succeeded very well, and it will be obvious why this should be so, since there are a very large number of small apertures in a car, both inlets and outlets, all of which are elements in the problem. No window or door is tight, and even though the velocity of the air going out of the ventilators is measured, the friction against the sides of the ventilators is such that it is very difficult to get an average figure for velocity. Accordingly another method has been employed, as follows:

A car is loaded with a definite number of inmates, and after a run under ordinary conditions a sample of the air from the car is secured and analyzed for carbonic acid. It may be supposed that the analysis shows twelve cubic feet of carbonic acid per 10,000 cubic feet of air. But four cubic feet are a normal constituent of the air, leaving eight cubic feet coming from the inmates of the car. If there were sixty of these and each one gives off carbonic acid at the rate of 0.60 of a cubic foot per hour, it is obvious thirty-six cubic feet per hour are to be dealt with and the problem becomes, "How much fresh air must be mixed with thirty-six cubic feet of carbonic acid from the car inmates, so that the resulting mixture would show on analysis eight cubic feet of carbonic acid from the same source per 10,000 of the mixture?" or in other words, if 10,000 cubic feet of air contains eight cubic feet of carbonic acid, how many cubic feet of air will be required to contain thirty-six cubic feet of carbonic acid on the same ratio? Reducing the proportion and it appears that under the conditions assumed, 45,000 cubic feet of fresh air per hour would pass through the car. In this illustration the amount of air in the car to start with is ignored, since it is not





an important element, and since results accurate to a few hundred cubic feet are not essential.

This brings us to the consideration of the ventilating system which has been adopted as standard by the Pennsylvania Railroad Company, and which is now in daily use on some 800 passenger coaches on the lines east of Pittsburg and Erie, and on nearly 200 coaches on the lines west of Pittsburg and Erie. It may not be amiss to say that the development of the system has taken several years of study. A very large number of experiments have been made. Each experiment led to modifications and changes, which were followed often by runs on the road, with analyses of air from the cars, the information obtained from each trial being used to lead to further modification, until a satisfactory result was obtained. Of course, the system as described is the one finally decided on. It will be noted by an examination of the plate that, taken as a whole, the system is extremely simple. It consists in taking air from the outside in through hoods located on what is known as the lower deck near the top of the car, and at diagonally opposite corners of the car. The opening of the hoods is toward the direction in which the car is moving, and, as will be noted a little later, the movement of the car is an element in the problem of getting the air into the car. The opening is covered with a gauze to exclude large cinders. The hood is fitted with a valve operated from the inside of the car in such a way that as the car changes direction the proper passageway is provided. From the hood the air passes through what is technically called a "down-take," about 100 square inches in area, which conducts the air down underneath the floor of the car to a passageway which occupies the space between the outside sill, the floor, the first intermediate sill and the false bottom. This space has an area of a little over 100 square inches, and extends the whole length of the car. From this space the air passes up through apertures in the floor into the heater boxes, where it is warmed. From the heater boxes the air passes out into tubes situated under each seat, and is delivered into the aisle of the car from the tubes. From these points it disseminates through the car, and finally passes out of the car through ventilators situated along the center line of the upper deck. These ventilators may be of any approved form. The kind most used thus far has been what is known as the "Globe Ventilator," which ventilator has the characteristic that when the car is moving through the air, or when the wind is blowing across the ventilator, a suction is produced on the air in the car. It will be observed from what has already been stated, that there are two things that cause the ventilating air to move through the car. First, the heating system. The ventilators in the upper deck are situated some two feet higher than the top of the hood, and accordingly, when there is heat in the car, or when the lamps are lighted, there is the proper ventilating movement of air through the car, due to this force. Also it will be noted that the movement of the car is an element in the problem likewise. The car movement produces pressure in the hood and down-take and the ventilators produce suction as has already been described, and these two acting together lead to change of air in the car. The control of the system, that is the means by which the amount of air passing through the car is diminished, is in the ventilators. Each ventilator is provided with a register, and when these registers are closed the total amount of air passing through the car is diminished a little over one-half. It will be observed that by partly closing all the ventilators, or closing a part of them, any intermediate figure between these two can be obtained. It is found essential to have a portion of the passageway in the ventilators over the lamps continuously open, in order to carry off the products of combustion. The register at no time closes this portion of the ventilators over the lamps.

The experimental work having led up to the construction finally decided on, it remained to actually put the system to test and see exactly what was being obtained. The first experiment was to see whether when the car was standing still, and heat was in the car, the movement of the air would be in the desired direction, namely, into the car through the hood, and out through the ventilators on the upper deck. With some systems of car ventilation where the movement of the air is almost wholly a function of the movement of the train, when the train stops the air movement is in the opposite direction, owing to the relation between the heating system and the ventilating system. In the system which we are dealing with this does not take place, for obvious reasons, namely, as has already been stated, the exits are higher than the in-takes.

The second test concerned the air from the closet. Some anxiety was felt as to whether the ventilating system would take air from the closet into the car. As a precautionary measure a small "Globe" ventilator was put in the roof of the closet, and also the proportions of parts of the system were designed in such a way that when the car was in service, there would be a plenum in the car produced by the hood rather than a vacuum produced by the suction of the "Globe" ventilators. As a matter of fact, the construction finally adopted gave very close to a balance between these two features. However, many experiments show without question that when the car is in motion, and the ventilating system in full operation, the air movement is toward the closet, instead of from it.

A third test of the system was to determine the actual amount of air passing through the car. In order to decide this question, a car fitted as above described was filled with men from the shops, who were paid for their time, under the charge of a foreman, so that they could be controlled in the matter of opening doors and windows, and a trip was made early in December from Altoona to Johnstown and return. Rubber bags and hand bellows were taken along with which to secure samples of the air in the car. Steam heat was necessary since the temperature outside was from 23 to 30 degrees Fahrenheit, and neither door nor window was opened during the trip, except that after the proper samples of air had been taken at Johnstown the men were allowed some freedom, since a wait of a couple of hours must ensue before the return trip could be made. The air samples for analysis were taken by pumping air into the rubber bags by means of the hand bellows, moving from one end of the car and back again in the aisle during the operation, and taking the air from about the level of the heads of the passengers. The analyses were made immediately after the return. In making the air analyses the carbonic acid only was determined, and from this was calculated the amount of fresh air taken through the car per hour by the ventilating system, the method used being the one described earlier in this article. As a matter of fact, there were fifty-two men in the car, and being workingmen it was assumed that they gave off 0.72 of a cubic foot of carbonic acid each per hour. The figures obtained on the trip mentioned are as follows:

WESTBOUND.

	Per cent. of carbonic acid	*Cubic feet of air per car per hour*
All Globe ventilators closed—Bennington	0.18	26,700
All Globe ventilators open—Buttermilk Falls ..	0.10	62,400
All Globe ventilators open—standing twenty minutes at Johnstown	0.21	22,000

EASTBOUND.

All Globe ventilators closed—Cresson	0.14	37,400
All Globe ventilators open—McGarvey	0.10	62,400
All Globe ventilators open—standing twenty minutes at Altoona	0.20	23,400

In explanation of the figures it may be stated that the stations mentioned denote locations at which air samples were taken. Bennington, on the schedule used, is about twenty-three minutes from Altoona; Buttermilk Falls is about fifty-seven minutes from Bennington, and Johnstown is about ten minutes from Buttermilk Falls. Returning, Cresson is about forty-two minutes from Johnstown; McGarvey about twenty minutes from Cresson, and Altoona about five minutes from McGarvey. These figures will give some idea of the interval between samples.

As has already been stated, the system was designed to give 60,000 cubic feet of air per car per hour, and it was felt that the figures given above show that the system fairly well fulfills the purpose for which it was designed. Not more than 60,000 cubic feet were planned for, for the reason that it was found impossible, as the result of experiments made early in the studies on this subject, to warm the large amount of air required by theory. While it would perhaps be possible to warm more than 60,000 cubic feet of air, yet it is always desirable to have some little factor of safety in the appliances used, and accordingly, after very careful consultation over the matter, it was decided not to attempt to get more than 60,000 cubic feet per car per hour.

Two points further were made the subject of test: First, the ability to keep the cars warm, even in the severest weather. This with the heating system, for which the ventilating system was designed, was found to be extremely satisfactory. Careful observations were made both on long runs and during severe cold blizzards on this point by competent persons, and at no time has there been any difficulty in keeping the car comfortable. Furthermore, the distribution of the heat in the car seems to be entirely satisfactory. Even under the influence of severe winds, not more than two or three degrees difference in different parts of the car are observable. It may be worth while to mention that, as will be noted from the description, the ventilating system consists of two halves, which are entirely independent of each other, except that the heating system on the two sides takes steam from the same point. Careful experiments with cars on the road indicate that when the wind is directly ahead, the two sides of the car take in approximately equal amounts of fresh air. When the wind, however, is to the right of the line of motion of the car, that side of the car seems to do most of the ventilating, and when it is to the left, that side does the most of the ventilating. This will be readily understood from the construction. The curvature of railroads, however, is so great that this fluctuation in the amount of fresh air taken in on the two sides does not, as already stated, seriously affect the temperature in different parts of the car.

The final test made has been as to the ability of the ventilating system to exclude objectionable matter, such as smoke, cinders and dust. A good deal of interest was felt over this matter at the start, and it is to be confessed that anything which is fine enough to be carried in the air will ultimately find its way into the car. As a matter of fact, it is found that small cinders which pass the gauze on the hood of the in-take are distributed more or less along the bottom of the space underneath the floor, and it occasionally becomes essential to clean these cinders out. Also in going through tunnels, sometimes smoke and gases are taken into the car in small amount. To meet this difficulty a butterfly valve was put in the down-take, and the instructions provide that this shall be closed when going through tunnels. Furthermore, the air being taken from near the top of the car, dust rarely gets high enough to cause any trouble. Smoke from the locomotive usually is either diverted by the wind, or is high enough not to reach the in-takes, so that, as a matter of fact, less difficulty has been experienced from objectionable material going in along with the fresh air than was feared. Finally, the air in the car being completely changed once in four minutes, it is evident that the inconvenience from temporary foul air going into the in-takes is reduced to a minimum.

The system as described has been in daily use on more or less cars, for now some five years, and the criticisms leading to modifications have been less than might have been expected. The system is being applied to all new cars as fast as they are built, and to other cars in the equipment as fast as circumstances will admit. It is unfortunate to be compelled to say that the system has not yet been applied to a sleeping car.

Altoona, Penna., April 7, 1904.